Ann Ig 2019; 31: 436-448 doi:10.7416/ai.2019.2305

Hospital environment as a reservoir for cross transmission: cleaning and disinfection procedures

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Key words: Healthcare associated infections, hospital environment, hand hygiene, disinfection
Parole chiave: Infezioni correlate all'assistenza, ambiente ospedaliero, igiene delle mani, disinfezione

Abstract

Background. *Healthcare associated infections (HAIs) represent a serious problem for public health, as they increase the morbidity and mortality rates, present a relevant financial burden, and significantly contribute to the antimicrobial resistance.*
Methods. *The aim of this review was to investigate the literature about HAIs, with particular reference to hospital environments and the role of cleaning and disinfection procedures. Hospital environments are an essential reservoir for HAIs cross transmission, and the application of appropriate procedures related to hand hygiene and disinfection/sterilization of surfaces and instruments remain key strategies for controlling HAIs.*
Results. *Different procedures, based on the risk associated with the healthcare procedure, are recommended for hand hygiene: washing with soap and water, antiseptic rubbing with alcohol-based disinfectants, antiseptic and surgical hand washing. Environmental surfaces can be treated with different products, and the mostly used are chlorine-based and polyphenolic disinfectant. The reprocessing of instruments is related to their use according to the Spaulding's classification. In addition, scientific evidence demonstrated the great relevance of the "bundles" (small set of practices performed together) in controlling HAIs.*
Conclusions. *Research agenda should include the improvement of well-known effective preventive procedures and the development of new bundles devoted to high-risk procedures and specific microorganisms.*

Introduction

Healthcare associated infections (HAIs) remain an issue of great concern for public health. These infections, already known as "nosocomial" or "hospital", are defined as infections that occur in patients during the process of care in a hospital or other health care facilities, not present or incubating at the time of admission. These infections increase the morbidity and mortality rates and present a not negligible financial burden; in addition, they significantly contribute to the antimicrobial resistance (1). With regards to their frequency World Health Organization (WHO) estimated that, globally, HAIs are the most frequent adverse outcomes during care delivery and no countries were

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able to completely eliminate this problem. Consequently, each year, hundreds of millions of individuals are affected by HAIs worldwide (2). According to the Centers for Diseases Control (CDC) of Atlanta, every day about one in 31 hospital patients has at least one HAI. During the course of 2015, 3% of hospitalized patients in United States had one or more HAIs for a total of 687,000 cases; about 72,000 hospital patients with HAIs died during the hospitalization (3). Based on large studies from USA and Europe, HAIs incidence ranged from 130 to 203 episodes per 1000 patient-days and pooled cumulative incidence was about 170 episodes per 1000 patient-days in adult high-risk patients in industrialized countries (4).

Regarding the current frequency of HAIs, in European countries the prevalence ranges from 7.6% to 10.3%, but this percentage is strongly related to influencing variables such as hospital's dimension, kind of department, days of hospitalization and preventive measures. In addition, prevalence changes from one European country to another and varies over the decades (5). Indeed, the HAIs prevalence estimated during the course of the years 1995-2010 extensively varied in different European countries: in UK was about 9.0%, while in Germany was about 3.6%, in Italy 6.7%, in France 4.4%, in Spain 8.8%, in Netherlands 7.2% and in Switzerland 8.8% (4). Besides, a study performed on Greek HAIs demonstrated that the 10% of hospitalized patients had a HAI, and many infections were determined by antibiotic-resistant opportunistics and/or pathogens (6). In the same period, the low- and middle-income countries presented a prevalence ranging from 5.7% to 19.1%. In particular, the highest prevalence was recovered in Albania (19.1%), followed by Mali (18.7), Tunisia (17.9%), Brazil (14%), Turkey (12.5%), Indonesia (7.1%) and Ghana (6.7%) (4). Furthermore, a study carried out in India, in a tertiary care hospital, reported a HAIs prevalence equal to 11.7% (7). However, these data cannot be considered as totally accurate because, in general, it is difficult to estimate the real frequency of HAIs. Furthermore, in low- and middle-income countries, a regular surveillance of HAIs is difficult to perform, and studies devoted to this issue are lack.

As regard to the Italian situation, there are some data reported by specific researches. A multicenter study, conducted in 2004 by the Italian National Institute of Health on 50 hospitals for a total of about 6,000 patients, reported that more than half of studied patients had an infection during the hospitalization. Southern Italy and Italian major islands presented the largest percentage of HAIs (48%), followed by northern and central Italy (respectively 30% and 22%) (8). These percentages are higher respect to those reported by other studies and international data, probably because of different definition of the "HAI case". Another Italian study, performed in 2011 on some Sicilian hospitals, reported a prevalence of HAIs equal to 3.2 for 100 patients compared to national prevalence equal to 6.3 for 100 patients (9).

Even if data on frequency of HAIs are heterogeneous, HAIs are a global problem and, thus, their financial burden cannot be neglected, both in term of direct and indirect costs (10). First of all, HAIs can extend the hospital stays' length and increase the costs for healthcare assistance. In a multi-center study conducted in China, the average length of hospital stay was 21 days in patients with HAIs compared to 16 days on average for patients without HAIs, resulting in a hospitalization cost of about € 700 more for patients with HAIs respect to those not affected (11). Similarly, in other countries HAIs determines relevant annual financial loss: it has estimated that only direct costs were about € 7 billions in Europe and $ 6.5 billions in the United States (12). Besides, HAIs cause also indirect costs as lost productivity of affected patients.

Another important problem related to HAIs is their role in the occurrence of the antimicrobial resistance. Indeed, the well-known widespread use of antibiotics has led to the development of resistant microorganisms, especially in the healthcare setting (13). In the United States, for example, many hospitals reported an increase in infections caused by Methicillin-Resistant Staphylococcus Aureus (MRSA) and Vancomycin Resistant Staphylococcus Aureus (VRSA) (14). Likewise, a recent study performed on European data demonstrated that 63.5% of infections with antibiotic-resistant bacteria were associated with healthcare, suggesting that infections with antibiotic-resistant bacteria mostly occur in hospitals and other health-care scenarios; particular concern is given to the Italian situation, because Italy had the highest estimated burden of antibiotic resistant bacteria than other European countries (15, 16). Besides, HAIs caused by multi-drug resistance micro-organisms also frequently occurs, making infection's treatment more difficult and expensive (17).

The staff and the health environment represent the intermedia transmission vectors of infections correlated to the multidrug resistant care (18). For all the reasons reported above, appropriate prevention strategies are needed in order to control the occurrence of HAIs.

The aim of the present review was to investigate literature data about healthcare associated infections, with particular reference to the hospital environment and the role of cleaning and disinfection procedures.

Hospital environment as a reservoir for cross transmission

"Healthcare" organization consists of the following three fundamental elements: the structures or areas where patient care is taken, the tools, materials and devices used for carrying out patient care and safely manage the building, and people circulating in these environments (patients, staff and visitors) (19). Each of these elements contributes to increase the risk of microbiological contamination of the hospital environment and, thus, determines a potential reservoir for the cross transmission of HAIs.

First of all, hospital's areas and structures undergo construction and renovation routinely and extraordinarily, such as the removal of an old elevator or the cleaning of the elevator horn, that can contaminate the air, the water and surfaces (20, 21). Besides, environmental surfaces, that are all the surfaces that do not come into direct contact with patients during care (i.e. x-ray machines, instrument carts or floors, walls, tabletops, etc.), objects and medical devices using for patients' care (i.e. blood pressure cuffs, stethoscopes, electronic thermometers, infusion pumps, and hemodialysis machines) can be contaminated and, consequently, represent a potential vehicle of microorganisms' transmission (20, 21). Patients often come into contact with microorganisms that can resist on the surfaces and in the environmental matrices (air, water) for a variable period of time (sometimes a long period of time). The type and quantity of these depends on the characteristics of the built environment, the circulation of personnel, patients and visitors, the climate conditions (in particular the survival of these microorganisms is strongly influenced by the degree of humidity), the presence of surfaces and equipment consisting of materials that promote microbial growth and survival, from the rapidity at which they are removed from the air and from the correct implementation of all the expected hygiene standards. In particular, it should be emphasized that gram-positive bacteria survive more easily in environments (but also on surfaces) that are dry, unlike gram-negative (as well as fungi) that survive mainly in dirty and wet environments (22).

As regards to the microorganisms present in the hospital settings, it is well-known that each hospital has a particular "biological imprinting"; however, there are some bacteria more present and/or hazardous respect to others. Among these, *Legionella* spp. is a relevant microorganism for hospital environments; it is a gram-negative bacterium that can naturally be found in hot and/or cold water; consequently, water systems, wet ground, air conditioning systems, cooling towers, spas, pools and fountains are at higher-risk to be contaminated. Transmission of *Legionella* spp. occurs by the inhalation of droplets containing the bacterium. Biofilm accumulation promote algae and protozoa proliferation, providing essential nutrients for *Legionella* and interfering with the action of disinfectants; thus, the formation of biofilm is a main risk factor for *Legionella* colonization and survival. Hospital water distribution systems are at higher-risk of *Legionella* contamination (23, 24). Approximately 28.2 cases of legionellosis per million inhabitants were estimated in 2016 in Italy (95% of cases were community-acquired and 5% were HAIs) (25). Other relevant microorganisms potentially present in water lines and associated to HAIs are mycobacteria. Scientific literature reported different species of mycobacteria associated with nosocomial infections through water transmission, including *Mycobacterium (M.) avium complex, M. fortuitum, M. gordonae, M. marinum, M. scrofulaceum, M. terrae, M. ulcerans* and *M. xenopi*, *M. chelonae, M. immunogenum, M. abscessus, M. kansasii, M. ulcerans, M. Szulgai, M. simiae, M. palstre*. (26). These bacteria can cause an immuno-mediated pulmonary disease or a direct infection, with colonisation of the respiratory tract. The latter occurs mainly but not exclusively in patients previously affected by structural pulmonary diseases (i.e. chronic obstructive pulmonary disease), which can also determine the deaths of these patients (27). Another rapidly growing bacterium of the same species presents also in tap water, named *M. porcinum*, can cause wound infections, related to the use of intravascular catheter and/or osteomyelitis (28). Regarding this specific microorganism, it is important to note that, in the last years, mycobacteria, especially *M. tuberculosis,* become multidrug or pandrug resistants, determining incurable infectious diseases (29).

Another microorganism that causes a great number of HAIs is the *Clostridium (C.) difficile*, a gram-positive, spore-forming bacterium, transmitted by fecal-oral pathway both in direct and indirect mode. Antibiotic therapies often alter normal intestinal flora, causing an excessive proliferation of this bacterium, whose spores can survive on clothes, surfaces, bodies or devices of health workers for a long period of time (up to five months). Therefore, the contact with contaminated surfaces, devices, or hands increases the risk of infection (30). As an example, *C. difficile* is found in 90% of the bathrooms used by *C. difficile* positive individuals. The prevalence of *C. difficile* asymptomatic colonization was found about 10 times higher in hospitalized patients (10-25%) than in the healthy population (2-3%) (31). The risk increases if the previous occupant or a roommate is positive for *C. difficile*, or the roommate is receiving antibiotic therapy (32).

Another microorganism commonly associated to HAIs is *Klebsiella (K) pneumoniae*, a cause of pneumonia, bloodstream infection, wound or surgical site infections, and meningitis. *Klebsiella* is normally present in the human intestine (where it does not cause disease) and, therefore, is often found in human stool. It is unusual that healthy people get *Klebsiella* infections, while patients are at risk undergoing treatment with ventilators, catheters intravenous or undergo long antibiotic treatment. It should also be reported that this bacterium developed a certain resistance to carbapenem and cephalosporins (33, 34). For example, in 2016 in France, it was reported that 29% of detected *K. pneumoniae* was resistant to third-generation cephalosporins (35).

Another Gram-negative bacterium related to HAIs is *Acinetobacter (A.) baumannii*, an anaerobic coccobacillus able to colonize many districts of the human body such as intestine, throat and skin, and able to survive in the environment even up to one month. It is recognized as an important cause of respiratory, urinary, hematic and wound infections associated with a high mortality rate (36).

A. baumanni is often resistant to many antibiotics, determining a serious problem for the treatment of these infections. It seems that the most effective treatment is represented by polymyoxins in monotherapy or in combination with other agents. A recent meta-analysis shows that there is no improvement in the rates of healing or mortality when polytherapy is used respect to monotherapy, even if the rates of microbiological eradication result higher (37).

The problems connected to the most appropriate choice for a therapy, considering the growing resistance of this bacterium, lays the foundations for the study of prevention measures to avoid or limit the spread of *A. baumanni*, paying particular attention to hand hygiene and environmental disinfection (38).

Gram-negative bacteria causing HAIs include also *Pseudomonas (P.) aeruginosa*, a microorganism commonly found in water and soil or as an opportunistic pathogen of humans, animals and plants. *P. aeruginosa* causes HAIs especially in subjects who are already immunosuppressed, particularly if they are ventilated or intubated or treated with contaminated solution, and mainly by burns or cystic fibrosis (39, 40). Therefore, its transmission is both environmental but also through direct contact or through droplets released by coughing and sneezing from already infected people (39). Besides, cases of *Pseudomonas* infections have been reported as a result of using infected bronchoscopes. For this reason, although periodic monitoring of clinical endoscopes is not currently prescribed as a routinely practice, CDC promotes the cultural surveillance of duodenoscopes in addition to the reprocessing procedures. For this reason, it is important to promote the microbiological surveillance of bronchoscopes in order to prevent nosocomial infections transmitted through the use of infected bronchoscopes (41).

An important cause of mortality in hospitals is Methicillin-Resistant *Staphylococcus aureus* (MRSA). Previously present only as infections acquired in health facilities, a community-associated variant (CA-MRSA) has also been found (35, 42). Indeed, bacteremia determined by *Staphylococcus aureus* causes 20-30% of hospital mortality. If despite targeted antibiotic therapy positive cultures and fever are still present after 72-96 hours, it is appropriate to suppose a complication such as endocarditis or septic thrombophlebitis. For this reason, it is necessary to monitor body temperature and sample blood cultures every 24-48 hours in order to identify the focus early and act towards an eradication (43, 44).

Other relevant causes of HAIs are *Enterococcus* and *Staphylococcus epidermidis*, mycetes (in particular *Candida* and *Aspergillus*), the multi-resistant *Pneumococcus*, the vancomycin-resistant *Enterococcus*. Among the gram-negative bacteria, *Escherichia coli* and *Proteus mirabilis* show resistance to broad-spectrum of beta-lactamases. In addition, *Enterobacter* and *Citrobacter freundii* are resistant to third-generation cephalosporins (5). In particular, enterobacteria represent one of the main causes of hospital mortality, as they cause bloodstream infections and their extended-spectrum production of β-lactamases complicates antibiotic therapy (45).

In addition, among the fungi, *Aspergillus* is an important cause of death among severely immunosuppressed patients. The incidence of nosocomial infections caused by *Aspergillus* has been correlated with the contamination of surfaces and air by pathogen, suggesting the relevance of the environmental control and surveillance interventions in high-risk departments, that should promptly highlight an inadequate functioning of the conditioning systems and activate the procedures for adequate cleaning and disinfection to prevent fungal contamination (46).

Breaking the transmission chain of HAIs in hospital environments by cleaning and disinfection procedures

Hand hygiene

Healthcare operators' hands are the most relevant vehicle for transmitting HAIs (47). Thus, hand hygiene is the first and fundamental action to manage their occurrence. In this regard, a study conducted in England showed that Muslim patients wash their hands very frequently for religious reasons compared to patients belonging to other religions. This difference was associated with the lower incidence of *C. difficile* infections that occur in Muslim patients (48).

According to WHO (49) and the United States Centers for Disease Control and Prevention (CDC) (50), hand hygiene should be carried out with different methods based on the risk associated with the actual healthcare procedure: washing with soap and water, antiseptic hand washing, antiseptic rubbing with alcohol-based (foams or gels) hand disinfectants, and surgical hand washing.

Adherence to hand hygiene procedures among personnel is very variable, ranging between 5% and 89% worldwide, with a total average of about 38% (49). Health workers recognize in the lack of time, in being overburdened by work and in the excessive bureaucracy an important role for not fully observing hand hygiene procedures. A recent survey, carried out in a large hospital in Vietnam, highlighted that the main barriers for the adherence to the guidelines for hand hygiene were the lack of adequate products and their improper positioning, patients overcrowding, work overload, skin reactions caused by some antiseptics, lack of risk perception, old habits and forgetfulness (51).

In order to overcome these barriers to hand hygiene among healthcare personnel, several time-saving and skin-care antiseptic products are available. In particular alcohol-based gels or foams added with emollients and chlorhexidine may increase the compliance to hand hygiene procedures also because water rinsing is not needed (52).

However, it is important to underline that the use of these products cannot replace the use and the change of gloves between a patient and the following one. Besides, targeted hand hygiene procedures are needed when the presence of a specific microorganism requires the use of a particular biocide. In these cases, hand-washing with soap and water followed by antisepsis is recommended (47, 49).

Environmental surfaces disinfection

The role of contaminated health care surfaces on the risk of HAIs for patients has long been debated but, nowadays, it is well-recognized that the environment may contribute to the transmission of many health care-associated microorganism, such as *C. difficile*, vancomycin-resistant enterococci (VRE), MRSA, etc. Indeed, these bacteria may pass from contaminated patients and staff to environmental surfaces and persists on these surfaces for days, increasing the possibility of transmission for other patients. For these reasons, scientific evidence has demonstrated that an appropriate surface disinfection is a key procedure for reducing HAIs' incidence (53, 54).

Among the available environmental disinfectants, chlorine-based and polyphenols products are the most widely used in hospital settings (55, 56). On the contrary, alcohol-based products cannot be used for large surfaces due to their short persistence and the risk for safety and health consequent to vapor generation (57).

As regard to chlorine-based products, hypochlorite and sodium dichloro isocyanurate at various concentrations (ranging from hundreds to thousands of ppm) are used for controlling microbiological contamination of corridors, common areas, wards, toilets, operating rooms, etc. However, the use of chlorine products usually needs an accurate preliminary cleaning to reduce surfaces' contamination due to organic matter that decreases the concentration of the active principle. Recently, some chlorine-based products containing a surfactant were made available (55).

Besides, chlorine derivatives can damage different types of materials. The use of sodium dichloroisocyanurate solutions may overcome most of these problems (58).

Products based on a mixture of two or three different phenols added with surfactants (the so called "polyphenols") can be used for environmental surfaces' disinfection in the same areas of the hospital settings. Main advantages of these products, when compared to those chlorine-based, are the "one-step", that is cleaning and disinfecting in a single treatment, the higher surficial persistence and the absence of damages on surfaces. On the other hand, their spectrum of action is less wide and they cannot be used at high concentrations. In addition, polyphenols are recognized as effective decontaminants for environmental areas contaminated by *M. tuberculosis* (30).

Other several technologies have proven to be effective for disinfecting environmental surfaces, such as hydrogen peroxide steam, ultraviolet (UV) light and copper and silver coated surfaces. Unfortunately, these techniques cannot be applied to large surface because of technological and practical reasons. Some photocatalytic antimicrobial coatings are currently recognized as useful for their capability to promote the production of reactive oxygen species with consequent antimicrobial effects under light exposure. Several nanotechnological solutions are improving this approach by expanding the available photocatalytic surface of different products mainly based on Titanium Dioxide. A promising application of photocatalytic materials in hospital settings is aimed to prevent HAIs by reducing the microbial load in indoor environments. Recent studies on antibiotic resistance bacteria showed the effectiveness of this strategy in reducing the risk of MRSA infection (59).

Disinfection and reprocessing of reusable medical devices

According to the recommendation of 2008 CDC guidelines, the reprocessing of reusable medical devices should involve a preliminary cleaning. This pre-treatment should be performed immediately, just where the instrument is used, to avoid the drying of biological material that could make the reprocessing process fail. This preliminary procedure consists of a cleaning with water and detergent or water and enzymatic detergent (60). The following step consists of sterilization, high level or standard disinfection, depending on the risk related to the specific use of the equipment. Taking into account the well-known Spaulding's classification of patient care equipment, medical and surgical material can be classified as critical, semi-critical and noncritical (61). The use of critical devices provides the contact with sterile tissues and vascular circulation; for this reason, a sterilization treatment is essential for these devices. In particular, if the critical instrument is not likely to be damaged by heat, steam, pressure or humidity, the steam or heat sterilization is considered the gold standard procedure. Otherwise, other low temperature methods such the use of ethylene oxide, plasma gas or peracetic acid immersion are recommended (62).

The semi-critical materials come in contact with mucous membranes (gastroscopes, instruments for respiratory therapies) need for a high-level disinfection treatment. Even in this case, steam sterilization is the gold standard; as many of these items are temperature sensitive, high level disinfection procedures based on low-temperature chemical treatments are necessary (63-65).

Noncritical materials come in contact with intact skin and, consequently, can be processed by a disinfectant that has an intermediate or low activity level, at the recommended concentrations (66-68).

In this context, a particular focus should be devoted to endoscopes as their reprocessing have many limitations due to their narrow lumen and multiple internal channels, as well as turning at right angles. In these internal surfaces, the bacteria are able to form biofilms. A recent multicenter Italian survey, involving 22 endoscopy units, reported that all studied hospitals performed treatments conform to the guidelines; in particular, 55.6% of these units used enzymatic detergents (as recommended by international guidelines) and the most widely used disinfectant was the peracetic acid; however, relevant differences were found with regard to the periodic quality checks (64, 65). This result highlights the need for improving the recommendations of applying appropriate procedures in the reprocessing of these devices.

Bundles

The term “bundle” refers to a series of practices that are used collectively because together they have much more satisfying results than whether they would use individually. In particular, a bundle is a structured way for improving the care processes and the patient outcomes. It is based on a structured and small set of evidence-based practices (usually three to five practices) performed together and constantly, in order to ensure the best possible care for patients (69). This approach, developed in 2001 by the Institute for Healthcare Improvement (IHI) in the USA for improving patient outcomes, was soon adopted also by other countries worldwide. For example, the NHS Modernisation Agency’s Critical Care Programme in UK take on bundles, specifying their characterizing elements respect to a checklist or a set of guidelines: all changes are necessary and sufficient, all changes are based on level 1 evidence, are accepted and well established, the changes are clear-cut and straightforward involving an all-or-nothing approach (70, 71).

Since their introduction, several bundles have developed for specific kinds of HAIs or high-risk procedures or species of microorganisms. As regard to the kind of HAIs, a recent systematic review and meta-analysis on the association of evidence-based bundles with surgical site infections (SSIs) rates after cesarean delivery demonstrated that bundles of three or more evidence-based interventions significantly decreased the risk of SSIs (72). Besides, several observational studies evidenced the importance of the bundle approach in the prevention of SSIs after other type of interventions. For example, Bert et al. demonstrated that the application of a 5-items bundle (infection risk index calculation, preoperative shower, trichotomy, antibiotic prophylaxis, and body temperature control) is associated to a substantial reduction in SSIs in the colon surgery (73). Similarly, another observational study evidence that a bundle including preoperative chlorhexidine shower, a transverse groin incision when clinically applicable and a chlorhexidine shower within two postoperative days when the dressings were removed determined a significant reduction in SSIs after lower extremity vascular bypass procedures (74).

Specific bundles have been developed for other high-risk procedures, such as the insertion and maintenance care of central lines in neonatal, paediatric, and adult ICU patients, that are associated with an increase of central-line-associated bloodstream infections; a systematic review and meta-analysis on this issue demonstrated a potential protective role of central-line bundles (insertion or maintenance or both) (75). In addition, HAIs associated to urinary catheters have been substantially reduced by the use of a "bladder" bundle including some practices and related measures such as nurse-initiated urinary catheter discontinuation protocol, urinary catheter reminders and removal prompts, alternatives to indwelling urinary catheterization, portable bladder ultrasound monitoring, insertion care and maintenance (76).

Regarding specific microorganisms, a recent study evidenced the significant reduction of paediatric healthcare-associated viral infections due to the development of targeted prevention practices formalized into a comprehensive prevention bundle (77). Other specific bundles that can be cited are related to *C. difficile* HAIs, even if until under evaluation (78).

Conclusions

This review shows that hand hygiene, disinfection procedures and bundles are essential strategies for one of the most important problem of public health, the HAIs occurrence. Indeed, this kind of infections are not totally well-controlled, especially in hospital environments. It is essential to improve the paradigm of the prevention strategies with an integrated approach, that involves appropriate procedures. Considering the most important risk factors associated to HAIs, hand hygiene and cleaning, disinfection or sterilization of surface and instruments are key preventing operations. It is important to note that the simultaneous application of proper procedures/measures/techniques has often a stronger effect respect to the application of the single intervention. This assumption is the rationale of the bundles, a set of practices and measures that must be used simultaneously. Since the risk of HAIs is different according to the procedures and the microorganisms of interest, research agenda should include the development of new bundles, specifically devoted to high-risk procedures and microorganisms.

Riassunto

Ambiente ospedaliero come reservoir per la trasmissione crociata: procedure di pulizia e disinfezione

Introduzione. Le infezioni correlate all'assistenza (ICA) rappresentano un rilevante problema di sanità pubblica in quanto aumentano i tassi di morbilità e mortalità, presentano un rilevante impatto economico e contribuiscono alla resistenza antimicrobica.

Metodi. Lo scopo della presente revisione è stato quello di indagare la letteratura sulle ICA, con particolare riferimento agli ambienti ospedalieri e al ruolo delle procedure di pulizia e disinfezione. L'ambiente ospedaliero rappresenta un essenziale *reservoir* per la trasmissione crociata delle ICA e l'applicazione delle procedure relative al lavaggio delle mani e la disinfezione/sterilizzazione di superfici e strumenti rimangono strategie chiave per controllare le ICA.

Risultati. Per l'igiene delle mani si raccomandano diversi metodi in funzione del rischio associato alla procedura assistenziale: lavaggio con acqua e sapone, antisettico e chirurgico, rubbing con disinfettanti a base alcolica. Le superfici ambientali possono essere trattate con diversi prodotti, maggiormente utilizzati sono disinfettanti a base di cloro e polifenoli. Il *reprocessing* di strumenti è correlato al loro utilizzo secondo la classificazione di Spaulding. Inoltre, le evidenze scientifiche hanno dimostrato l'importanza dei "bundles" (piccoli set di pratiche effettuate contemporaneamente) per controllare le ICA.

Conclusioni. Rilevanti *research agenda* includono l'implementazione delle procedure preventive note e lo

sviluppo di nuovi bundles per procedure ad alto rischio e/o specifici microrganismi.

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